MEMBRANE APPLICATION IN THE RECOVERY OF GAHARU ACTIVE MARKER COMPOUND FROM WATER MIXTURE

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V	Volume of permate
A	Effective area of membrane
P	Pressure of nitrogen gas
t	Time to collect permeate

LIST OF ABBREVIATIONS

FESEM	-	Field Emission Scanning Electron Microscope
HPLC	-	High Performance Liquid Chromatography
MF	-	Microfiltration
NF	-	Nanofiltration
UF	-	Ultrafiltration

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ABSTRACT

This study focuses the membrane application in the recovery of gaharu active marker compound from water mixture. The objective of this study is to design the separator process using membrane technique to recover gaharu active marker compound from water mixture and to analyse the recovered gaharu marker compound using membrane separation. The gaharu marker compounds that needed to be separated are agarospirol, jinkohol, α-guainene and selina-3,11-dien-9-al. Preparative High Performance Liquid Chromatography was used as the qualitative analysis of the gaharu active marker compound in the mixture. The membrane was applied to separate the marker compound from the water mixture. Milipore Stirred Ultrafiltration Cell Model 8200 was used as the membrane separation proces unit. Field Emission Scanning Electron Microscopy was used to capture microscope image of the TS40 and SB90 nanofiltration membrane used in the experiment. At the end of the experiment, TS40 nanofiltration membrane was able to separate the gaharu marker compounds at the average flux value of 0.45 ml/cm^2.h to 2.00 ml/cm^2.h with varying pressure from 1 bar to 4 bar.

APLIKASI MEMBRAN DALAM PEMULIHAN SEBATIAN KIMIA GAHARU YANG TERDAPAT DALAM CAMPURAN AIR

ABSTRAK

Kajian ini berfokus pada aplikasi membran untuk pemulihan sebatian kimia gaharu yang terdapat dalam campuran air gaharu. Objektif kajian ini adalah untuk mereka bentuk satu proses pemisahan menggunakan teknik membran untuk pemulihan sebatian kimia gaharu dalam campuran air and juga untuk menganalisis sebatian kimia gaharu yang telah melalui proses pemulihan menggunakan proses pemulihan membran. Sebatian kimia gaharu yang ingin dipisahkan adalah agarospirol, jinkohol, α-guainene dan selina-3,11-dien-9-al. Kromatografi Cecair Berprestasi Tinggin telah digunakan kualiti analisis untuk sebatian kimia gaharu dalam campuran air. Membran telah digunakan untuk memisahkan sebatian kimia gaharu dalam campuran air. "Milipore Stirred Ultrafiltration Cell Model" telah digunakan sebagai proses unit untuk pemisahan membran. "Field Emission Scanning Electron Microscopy" digunakan untuk menangkap imej mikroskop membran TS40 dan membran SB90. Di akhir experimen ini, membran TS40 dapat memisahkan sebatian kimia gaharu dengan nilai fluks purata dari 0.45 ml/cm^2.h hingga 2.00 ml/cm^2.h dengan tekanan dari 1 bar hingga 4 bar.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Gaharu or agarwood is one of the most famous incenses in the East. Gaharu are mainly produced by trees of Aquilaria and Gyrinops. The most popular species of Aquilaria in Peninsular Malaysia is Aquilaria Malaccensis. Gaharu oil is formed by mixtures of sesqiuternes, sesquiternes alcohol, chromone derivatives and resin (Adam et al. 2011). The important key components that contribute the aroma of gaharu are agarospirol, jinkohol-eremol, jinkohol and kusenol.

1.2 Problem Statement

Nowadays, membrane separation is one of the most popular methods of separation because of its capability. The use of membrane for separation is becoming increasingly important in the process industries. In this study, membrane is applied to separate the gaharu marker compound from the gaharu water mixture. A suitable set of membrane are needed to separate these marker compounds. The membranes are selected based on their pore size, permeability and selectivity.

The selected membrane to be used must be made up of compound that can have molecular interaction with the marker compounds that present inside the gaharu marker compounds. By using the correct compound, the membrane can pull the marker compounds into its surface and thus separating them from the gaharu water mixture.

1.3 Objective of Study

In this study, the objectives which aims to be achieved are :

1. To design the separator process using membrane technique to recover gaharu active marker compound from water mixture
2. To analyse the recovered gaharu marker compound using membrane separation
3. To make comparison between membranes that were used

1.4 Scope of Study

In this study, there are a few parameters that are needed to be controlled. The parameters include permeability and selectivity of the membrane, permeate flux and the pressure where these parameters will affect the membrane's performance in the separation process.

During the experiment, the membrane performance can affect how the marker compounds of gaharu are being separated and filter out. Therefore, it is important to know the concept of permeability, selectivity, mass transfer and diffusion process in a membrane system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

One of the objectives of this chapter is to explain the gaharu and its marker compound. Explanation on gaharu will be more detailed in the Aquilaria Malaccensis species which are found in Peninsular Malaysia. Then this chapter will explain the types of membrane that can be used in membrane separation.

The literature review is done based on the journals that are related Aquilaria Malaccensis species of gaharu. The literature review will cover the origins, types and characteristics of Aquilaria Malaccensis. This chapter will also cover the gaharu marker compound in its essential oils

The membrane application will also be covered in the scope of this chapter. Types of membranes, properties and their application will be explained in this chapter. There are three types of membrane that will be discussed here which are ultrafiltration, microfiltration and nanofiltration.

This chapter will let the reader to know the importance of gaharu and its marker compound. The concept of membrane separation will be explained to the reader.

2.2 History of Gaharu

Gaharu is a fragnant wood that is derived from the diseased timber of the genus Aquilaria. It is often occurs as dark coloured patches or streaks in the tree. Gaharu oil is greatly valued as perfume ingredient and incense because of its strong, unique scent and medical properties (Nor Azah et al. 2008).

Aquilaria genus is an aromatic plant that is commonly known as "Gaharu Wood" in South East Asia. The Aquilaria species is found mostly in Malaysia, Indonesia, India, Iran, Singapore, Bangladesh, Myanmar, Philippines and Thailand. One of the species, Aquilaria Malaccensis produces valuable resin marinate in the heartwood (Ibrahim et al. 2011).

Figure 2.1 Aquilaria Malaccensis Tree

Gaharu are classified into various grades such as Grade A, Grade B, Grade C and Grade D. Gaharu is graded according to their physical properties, formation and their unique scent (Nor Azah et al. 2008). Aquilaria Malaccensis produces valuable resin marinate in the heartwood which originates as a consequences of natural immune response towards fungal attack. One of the fungus, endophyte lives inside healthy plant tissues. Some of these endophytes have found to have anticancer and antidiabetic properties. Essential oils of Aquilaria Malaccensis is safe and simple to use. It is produced and commonly used in traditional medicine to relieve pain, fever, rheumatism, and asthma (Ibrahim et al. 2011).

2.3 Gaharu Marker Compound

The lower grades of gaharu such as Grade C are often distilled to get gaharu oil (Nor Azah, 2008). In an extraction process, the presence of main components such as agarospirol, jingkohol-eremol, jingkohol and eremol are found in gaharu essential oils. In this study, it is desired to separate four compounds from the gaharu water mixture using membrane separation. The four compounds are agarospirol, jinkohol, guainene and selina.

2.3.1 Agarospirol

Agarospirol is a chemical compound that consists of fifteen carbon atoms, twenty six hydrogen atoms and one oxygen atom. The molecular weight and volume are 222.366 and 183.5 respectively. This compound has five methyl groups and a functional group of hydroxyl.

Agarospirol is reported as one of the main marker compound that contribute to the scent of gaharu. Figure 2.2 represent the molecular structure of agospirol. Table 2.1 shows the chemical formula and molecular weight of agarospirol.

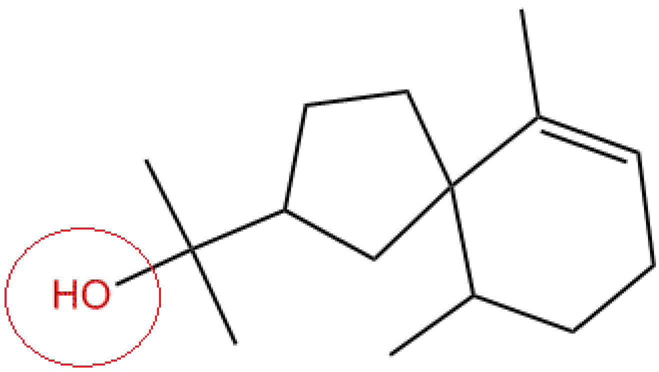

Figure 2.2 Molecular Structures of Agarospirol

Table 2.1 Properties of Agarospirol

Chemical Formula	Molecular Weight
$C_{15}H_{26}O$	222.366

2.3.2 Jinkohol II

Jinkohol II is a chemical compound that consists of fifteen carbon atoms, twenty six hydrogen atoms and one oxygen atom. The molecular weight and volume are 222.366 and 176.64 respectively. It has three methyl group and the functional group of one hydroxyl group.

Similar with agarospirol, jinkohol II is classified as the main marker compound in gaharu. Jinkohol II also contributes to the characteristic aroma of gaharu. Figure 2.3 represent the molecular structure of jinkohol II. Table 2.2 lists the chemical formula and molecular weight of the compound.

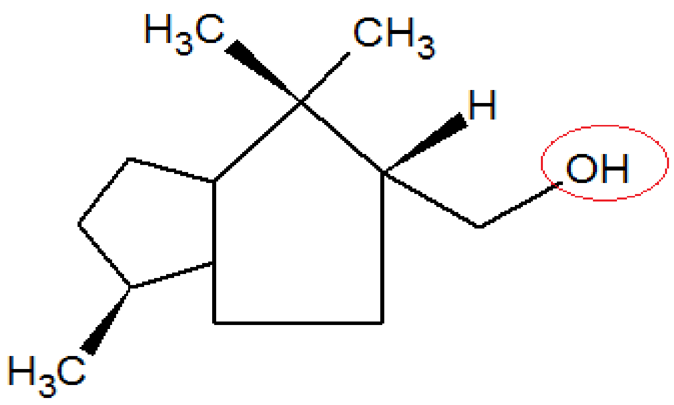

Figure 2.3 Molecular Structure of Jinkohol II

Table 2.2 Properties of Jinkohol II

Chemical Formula	Molecular Weight
$C_{15}H_{26}O$	222.366

2.3.3 α-guaiene

α-guaiene is a chemical compound that consists of five carbon atoms, five hydrogen atoms, five nitrogen atoms and an oxygen atom. The molecular weight and volume are 151.126 and 83. It has three double bonds.

α-guaiene is one of the main marker compound in the gaharu water mixture. Therefore it is one of the most important compound that present in the gaharu water mixture. Figure 2.4 represent the molecular structure of α-guaiene. Table 2.3 lists the chemical formula and molecular weight of α-guaiene.

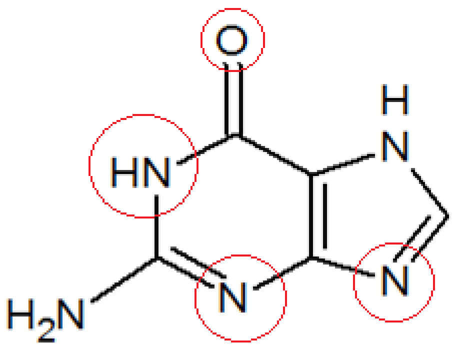

Figure 2.4 Molecular Structures of α-guaiene

Table 2.3 Properties of α-guaiene

Chemical Formula	Molecular Weight
$C_5H_5N_5O$	151.126

2.3.4 Selina-3,11-dien-9-al

Selina-3,11-dien-9-al is a chemical compound consists of hydrogen bonds and methyl groups. Similarly with other compounds that were explained above, selina-3,11-dien-9-al is also one of the main marker compound that present inside the gaharu.

The molecular structure of selina-3,11-dien-9-al has the functional group of hydroxyl. Figure 2.5 represent the molecular structure of selina-3,11-dien-9-al. Table 2.4 lists the chemical formula and molecular weight of selina-3,11-dien-9-al.

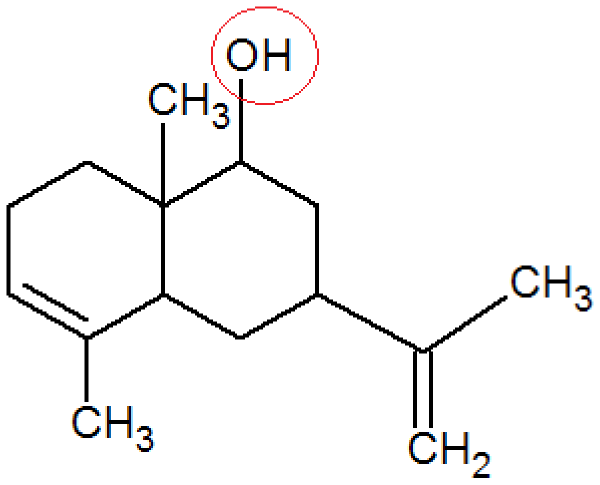

Figure 2.5 Molecular Structure of Selina-3,11-dien-9-al

Table 2.4 Properties of Selina-3,11-dien-9-al

Chemical Formula	Molecular Weight
$C_{15}H_{24}O$	220.35

2.4 Membrane Separation

2.4.1 Introduction

Membrane separation is becoming increasingly important in process industries. In this process, the membrane acts as a semi permeable barrier. The separation process occurs by the membrane controlling the rate of the movement of various molecules between two liquid phases, two gas phases, or a liquid or a gas phase (Geankoplis et al. 2003)

In this study, three types of membrane separation process will be discussed which are ultrafiltration, nanofiltration and microfiltration.

2.4.2 Advantage of Membrane Separation

Membrane separation can be used in a number of applications. One of the them is the separation of two chemical compounds in a mixture that have narrow boiling points. In the field of hydrocarbon separations, the separation of condensed olefin from corresponding paraffins is complicated process. Separation of paraffin and olefin by conventional distillation is expensive and difficult as the two substances has a narrow temperature ranges.

Therefore, membrane separation can be offered as an alternative for the separation process. In the polymeric matrix membranes, the introduction of chemically active sites can offer increase membrane selectivity and permeability. This can therefore improve in the efficiency of olefin and paraffin separations (Bessarabov et al. 1999).

Besides that, membrane separation can also be applied in the water and waste water treatment plant. A number of advantages can be offered by membrane processes over conventional water and waste water treatment processes. The advantages include reduced environmental impact of effluents, land requirement reduce, higher standards of final product and the potential of the mobile treatment units of membrane process.

In the water and waste water treatment, membranes can used in a few applications. The applications include removal of colour, trihalomethanes and other disinfection by product removal and also iron removal.

Membrane processes are also reported to be cost effective in a few situations and applications. It can be used as an alternative to conventional softening plant and as a pretreatment plant for reverse osmosis (Owen et al. 1995).